PERSEVERANCE SAMPLES FROM THE JEZERO UPPER FAN. B. P. Weiss[1], M. Nachon[2], K. Siebach[3], K. A. Farley[4], K. M. Stack[4], T. Bosak[1], J. F. Bell III[5], K. C. Benison[6], A. D. Czaja[7], V. Debaille[8], E. M. Hausrath[9], C. D. K. Herd[10], K. Hickman-Lewis[11], L. E. Mayhew[12], M. A. Sephton[13], S. F. Sholes[4], D. L. Shuster[14], S. Siljeström[15], J. I. Simon[16], M. Wadhwa[5], M.-P. Zorzano[17], [1]Massachusetts Institute of Technology, Cambridge, MA, [2]Texas A&M University, College Station, TX, [3]Rice University, Houston, TX, [4]Jet Propulsion Laboratory, Pasadena, CA, [5]Arizona State University, Tempe, AZ, [6]West Virginia University, Morgantown, WV, [7]University of Cincinnati, Cincinnati, OH, [8]Laboratoire G-Time, Université libre de Bruxelles, Belgium, [9]University of Nevada, Las Vegas, NV, [10]University of Alberta, Edmonton, Canada, [11]Natural History Museum, London, UK, [12]University of Colorado, Boulder, CO, [13]Imperial College London, London, UK, [14]University of California, Berkeley, CA, [15]RISE Research Institutes of Sweden, [16]NASA Johnson Space Center, Houston, TX, [17]Centro de Astrobiologia, INTA, Madrid, Spain.

Introduction: A key objective of the Perseverance rover mission is to acquire samples of Martian rocks for future return to Earth [1]. Eventual laboratory analyses of these samples will address key questions about the evolution of the Martian climate, interior, and habitability and enable the search for past life. The Perseverance rover is currently exploring the 45-km diameter impact crater Jezero crater situated in the Nili Planum region that formed sometime during the Early Noachian to Late Noachian (e.g., [2]). The geology of the western side of Jezero consists of a crater floor composed of lavas and cumulate rocks overlain by a sedimentary fan [3]. The fan is a remnant of a Late Noachian to Early Hesperian fluvio-lacustrine associated with a valley network that breached the Jezero western rim [4].

During four campaigns to the crater floor, fan front, upper fan, and crater margin, the rover has acquired igneous and sedimentary rock cores, a sample of the atmosphere and regolith samples. Here we focus on samples drilled during the Upper Fan Campaign that took places during sols 708-910 [5] (Fig. 1). We describe the samples' compositions, lithologies, and geologic contexts, focusing on their scientific promise for future returned sample science analyses.

Overview of upper fan samples: Planning for the Upper Fan Campaign in December of 2022 and January of 2023 led to a proposal to collect up to three singleton samples on a traverse between the fan front and the planned departure point from the northwest edge of the fan. The specific sampling targets of the Upper Fan Campaign were not precisely defined at the outset given uncertainty in whether the desired lithologies would be both available. The initial sampling priorities were as follows: one coarse grained (sand-sized and larger clasts) sample from the uppermost fan and additional to-be-determined samples. The latter, in priority order, were identified as clastic sedimentary rocks with dominant clay-sized grains, early diagenetic precipitates (e.g., silica or carbonate), and cobble or larger sized clasts with associated matrix. Lithologically exotic boulders from the Jezero catchment that will not likely

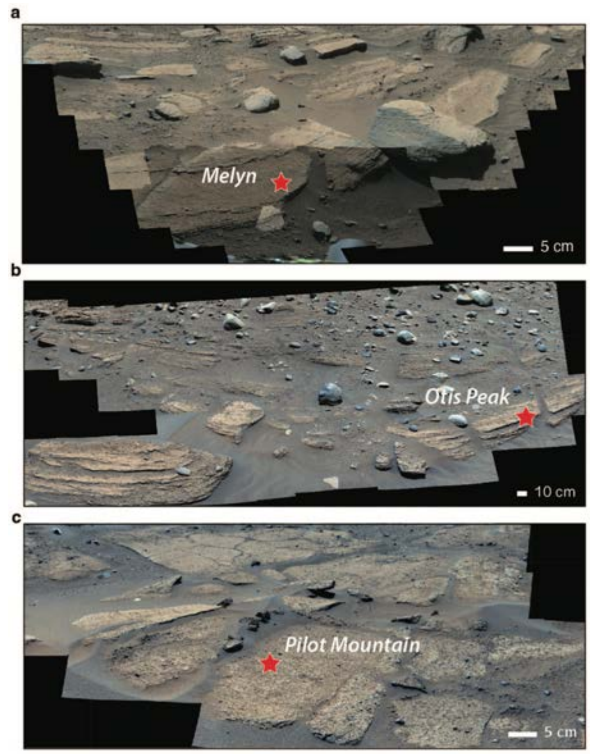

Fig. 1: Bedrock outcrops sampled by the Perseverance rover during the Upper Fan Campaign. (a) Berea workspace where Melyn core was drilled (star). Part of Mastcam-Z mosaic QZCAM_SOL0736SOL0739_ZCAM08745ZCAM0850_L0R0_Z110_TENBY_WORKSPACE_PDI_EXTENSION_ E01. (b) Hague Creek workspace where Pilot Mountain core was drilled (star). Part of Mastcam-Z mosaic QZCAM_SOL0821_ZCAM08838_R0_Z063_MOUNT_RICHTHOFEN_TONAHUTU_FRIGID_LAKE_EMERALD_LAKE_E01 (c). Emerald Lake workspace where Otis Peak core was drilled (star). Part of Mastcam-Z mosaic QZCAM_SOL0872_ZCAM08875_L0_Z63_DREAM_LAKE_POLYGONAL_OUTCROP_CONTEXT_PRE_BUMP_E01. Scale bars are approximate.

be visited by the rover were also recognized as potential sampling targets. In addition, the team aimed to acquire

samples from geologic units and time periods not previously sampled.

Three samples were acquired on the upper fan, all absolutely oriented cores of sedimentary bedrock [6-8]. In order of sampling and lowest to highest stratigraphic position, they are: Melyn, Otis Peak and Pilot Mountain. They are poorly sorted medium-grained sandstones with clasts ranging up to granule and pebble sizes. Their bulk compositions broadly match that of aqueously-altered basalt. The samples' low ultraviolet fluorescence intensity and the absence of obvious organic signals in ultraviolet Raman spectra suggest that any organics in the rock are present in low amounts. All samples are interpreted to be fluvial in origin and from upper part of the fan stratigraphy. An attempt to collect a sample from a pyroxene-rich boulder failed due to the hardness of the rock.

Sample descriptions:

Melyn: Melyn is a 60.4 mm long core acquired on sol 749 [6]. It was sampled from the delta-truncated curvilinear unit [9], which consists of amalgamated rhythmically layered light-toned resistant beds and coarser-grained more friable beds. Melyn has rare silicate clasts up to ~ 3 mm in diameter. Light tan-colored material observed between grains is likely cement. Its detrital materials include olivine, feldspar and possibly pyroxene, as well as minor chromite, magnetite, ilmenite, and phosphate. The presence of hydrated Fe-Mg sulfate, Ca-sulfate, Fe- and Ca-bearing carbonate, and potentially Fe-Mg-phyllosilicates, hydrated silica and hydrated Al-OH-minerals indicate a modest degree of aqueous alteration/diagenesis.

Otis Peak: Otis Peak is a 57.5 mm long core collected on sol 822 from the northeast side of a two-meter-high ridge capped by sand and boulders [7]. This location is within the delta-truncated curvilinear unit just below its contact with the boulder-rich, rubbly delta blocky unit [9]. Otis Peak is a polymict conglomerate (granule-pebble sandstone; with clasts up to 3 mm diameter) containing altered olivine as the major detrital mineral. Recognizable alteration products consist of Fe-Mg carbonate, Fe-Mg sulfate, Ca-sulfate, Fe phosphate, chloride minerals, potentially serpentine or other phyllosilicates, and hydrated silica or hydrated Al-OH-bearing minerals. Minor phases include iron oxides and possible Ca phosphate. The sample contains clasts with mineralogies not seen in previous samples, including one rich in Mg-carbonate, and monomineralic clasts of feldspars and Cr-spinels.

Pilot Mountain: Pilot Mountain is 60.0 mm long core collected on sol 882 [8]. Its stratigraphic position is uncertain but thought to be either from one of the uppermost lobes of the delta blocky unit, or else from the margin fractured unit, a carbonate-rich deposit along the crater's western edge [9]. If the former, Pilot Mountain is the stratigraphically highest and therefore youngest sample collected by Perseverance thus far. Pilot Mountain's major primary minerals are olivine, pyroxene, and feldspar. Also present are clasts of sulfate, low-Fe/Mg silicate, silica, Fe-Ti-Cr spinels and Ca-phosphate. Its matrix is composed of Fe-Mg carbonate, Fe-phosphate, and cross-cutting silica-rich (up to 77% SiO_2) material.

Importance of upper fan samples for returned sample science: Two aspects of the samples from the upper fan distinguish them from all other samples collected by Perseverance thus far. First, they provide the coarsest sedimentary material yet sampled by the rover. Second, they will likely be the youngest bedrock samples acquired during the Jezero prime and extended missions. The large clast sizes will enable multiple synergistic analyses of diverse lithologies likely sourced from the Nili Planum region outside Jezero crater, which contains some of the oldest known rocks on Mars (>~4 billion years old) (see [10]). Laboratory investigations of these samples will enable the study of a source-to-sink sedimentary system on Mars that will inform how aqueous processes and habitability evolved through time, both within the catchment and the fan. Crystallization ages of detrital igneous silicate clasts will provide upper bounds on the timing of fan deposition and therefore the timing of lake Jezero. Paleomagnetic studies [11] of the most ancient detrital grains could constrain the paleointensity of the early Martian magnetic field to test its hypothesized role in the loss of the early Martian atmosphere. Sedimentary cements and a diversity of aqueously altered clasts have the potential to preserve signs of life and/or the chemistry that gave rise to its origin [12].

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